(SEC) SINGAPORE-ETH CENTRE 新加坡－ETH 研究中心 | TUMCREATE

Project CONCEPT

CONne**C**ting District **E**nergy and **P**ower Systems in Future Singaporean New **T**owns

Sebastian Troitzsch, Sreepathi Bhargava Krishna - 13 March 2019

What is CONCEPT?

- CONCEPT stands for:
  - Connecting District Energy and Power Systems in Future Singaporean New Towns

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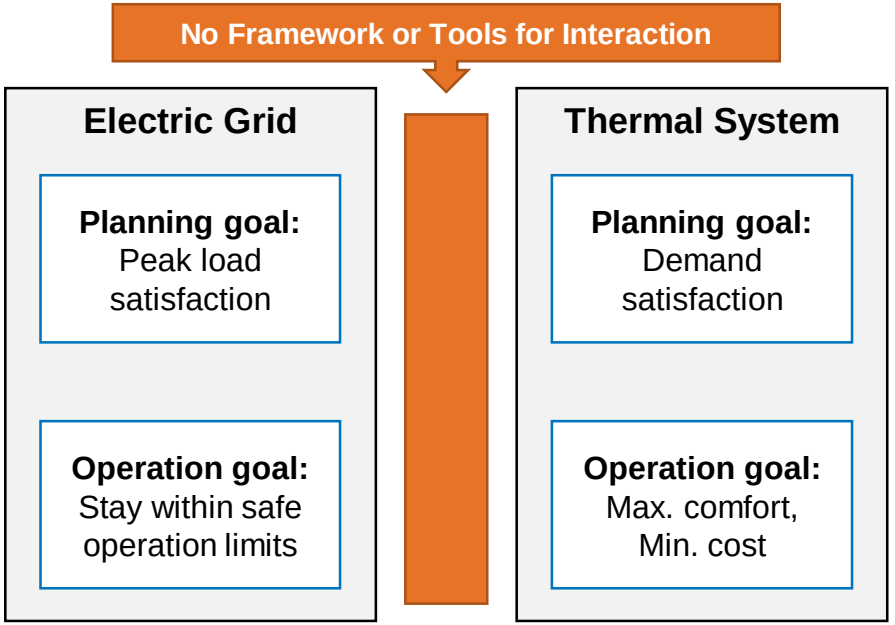
- Goals:
  1. Integrate **planning and operation of electric and thermal systems** on a district scale

Status Quo:



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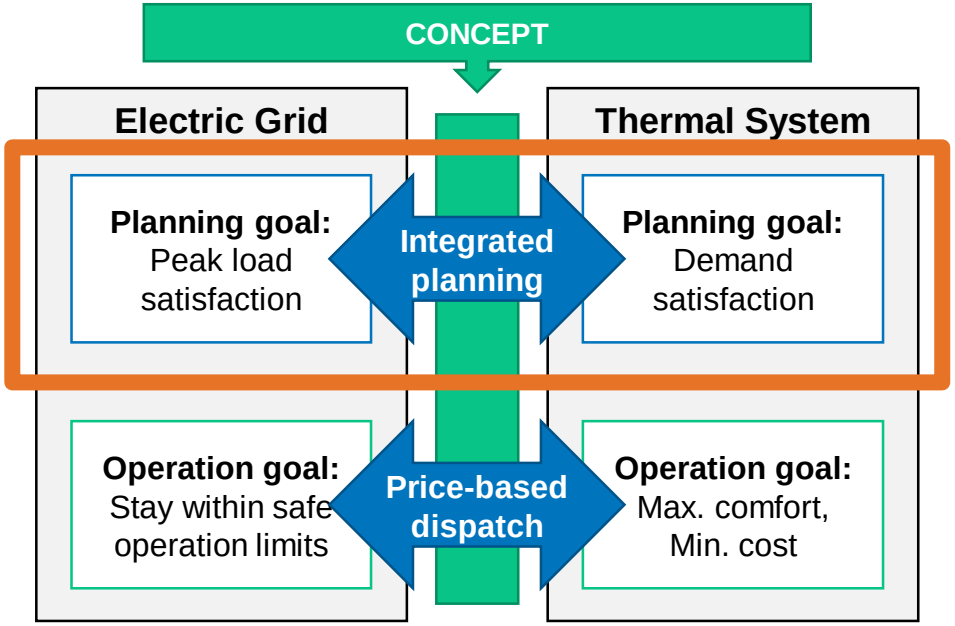
Proposal:



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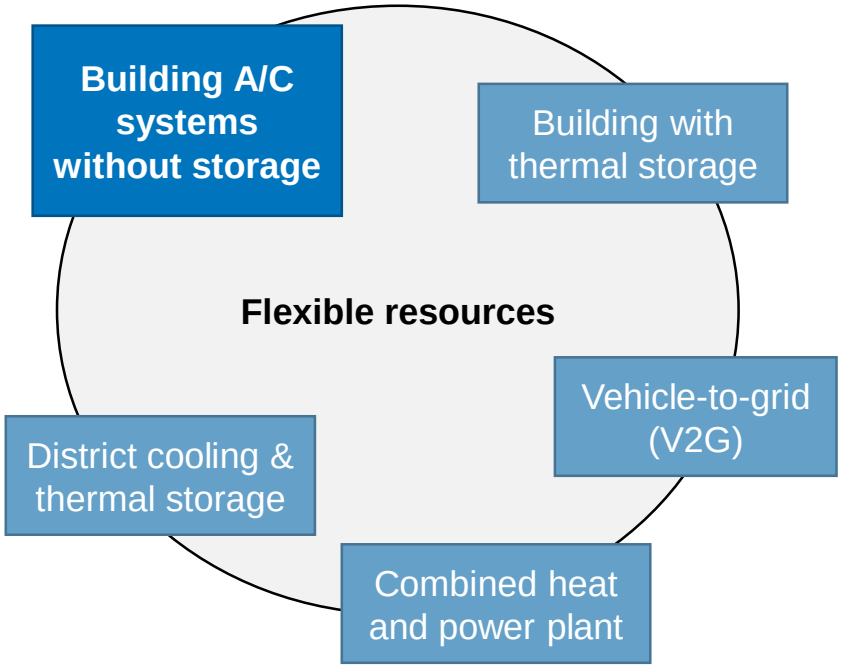
  1. Integrate **planning and operation of electric and thermal systems** on a district scale

  2. Consider **flexible resources in the planning phase** of New Town districts



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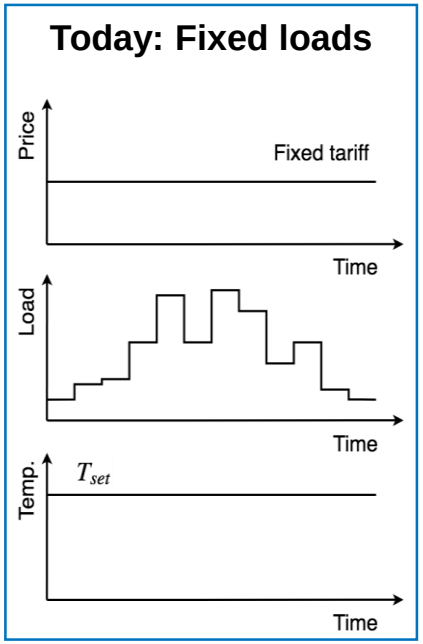

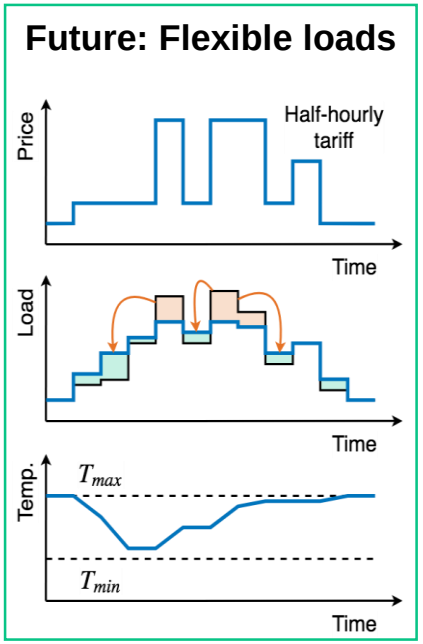

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  1. Integrate **planning and operation of electric and thermal systems** on a district scale

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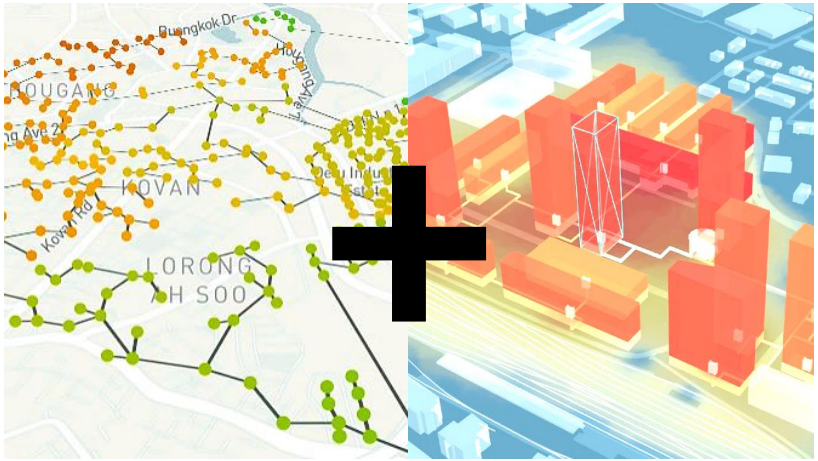
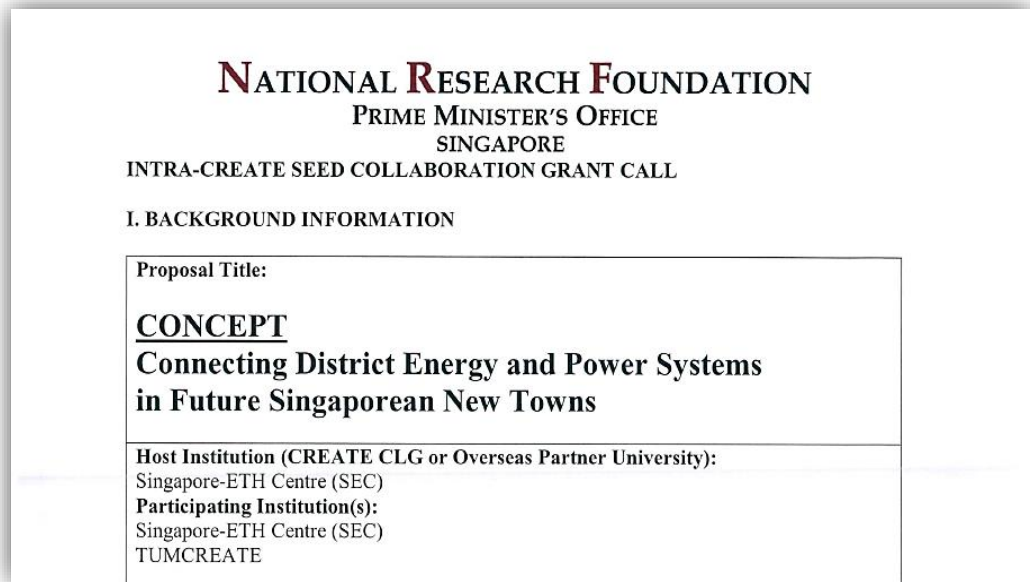
  3. Creating a **computational framework** integrated in City Energy Analyst (CEA)



What is CONCEPT?

CONCEPT is set up as **13-month pilot project** between the Singapore-ETH Centre (SEC) and TUMCREATE under the "**Intra-CREATE Seed Collaboration Grant**" of the National Research Foundation (NRF)



NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE
INTRA-CREATE SEED COLLABORATION GRANT CALL

I. BACKGROUND INFORMATION

Proposal Title:

CONCEPT
Connecting District Energy and Power Systems in Future Singaporean New Towns

Host Institution (CREATE CLG or Overseas Partner University):
Singapore-ETH Centre (SEC)
Participating Institution(s):
Singapore-ETH Centre (SEC)
TUMCREATE

Who is CONCEPT?

Sebastian Troitzsch
Researcher
(TUMCREATE)

Jimeno A. Fonseca
PI
(SEC)

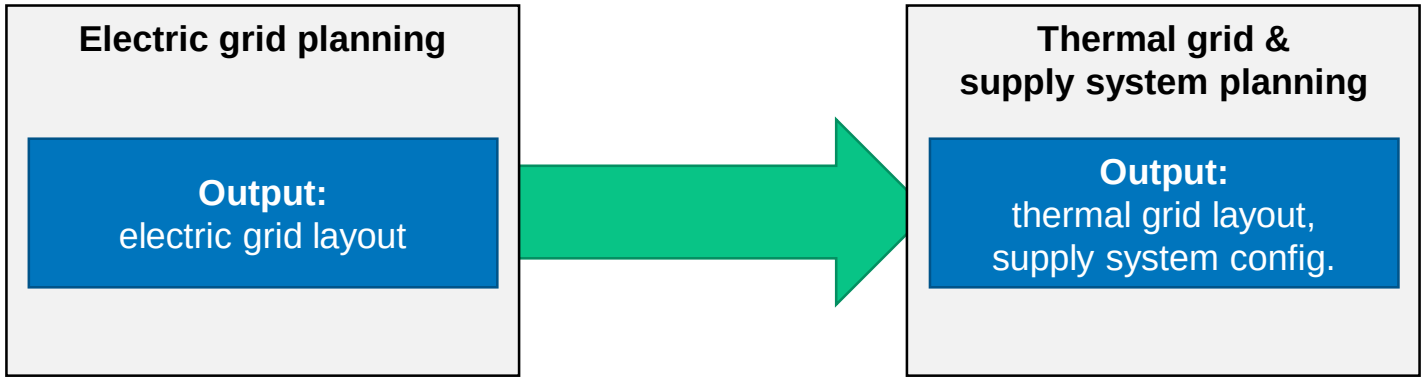
Tobias Massier
Adviser
(TUMCREATE)

Sreepathi B. Krishna
Researcher
(SEC)

Sarmad Hanif
Co-PI
(TUMCREATE)

Arno Schlueter
Adviser
(SEC)

Methodology



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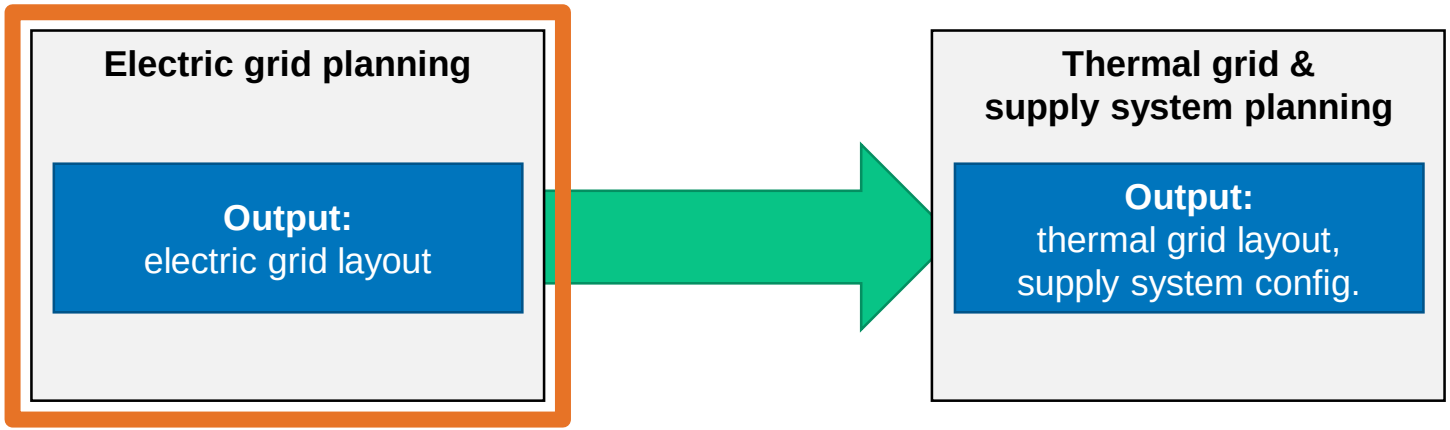

Methodology: Electric Grid Planning

Electric grid planning
considering flexible resource operation

Numerical optimization (linear program)

Minimize:

Investment costs for the electric lines, substation

+ Operation costs for flexible resources

Constraints:

Capacity limit of the electric grid

& Comfort constraints for flexible resources

Flexible resource models
(linear models)

Building A/C systems without storage

Building with thermal storage

Vehicle-to-grid (V2G)

Combined heat and power plant

District cooling & thermal storage

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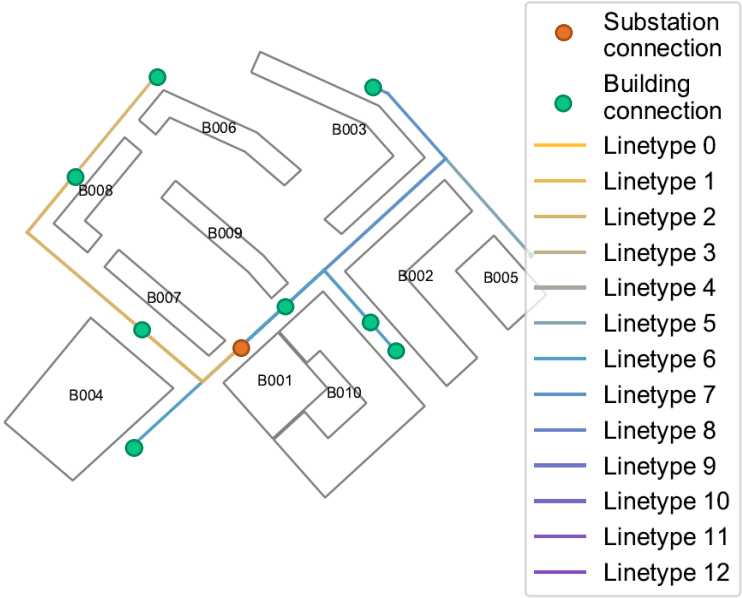

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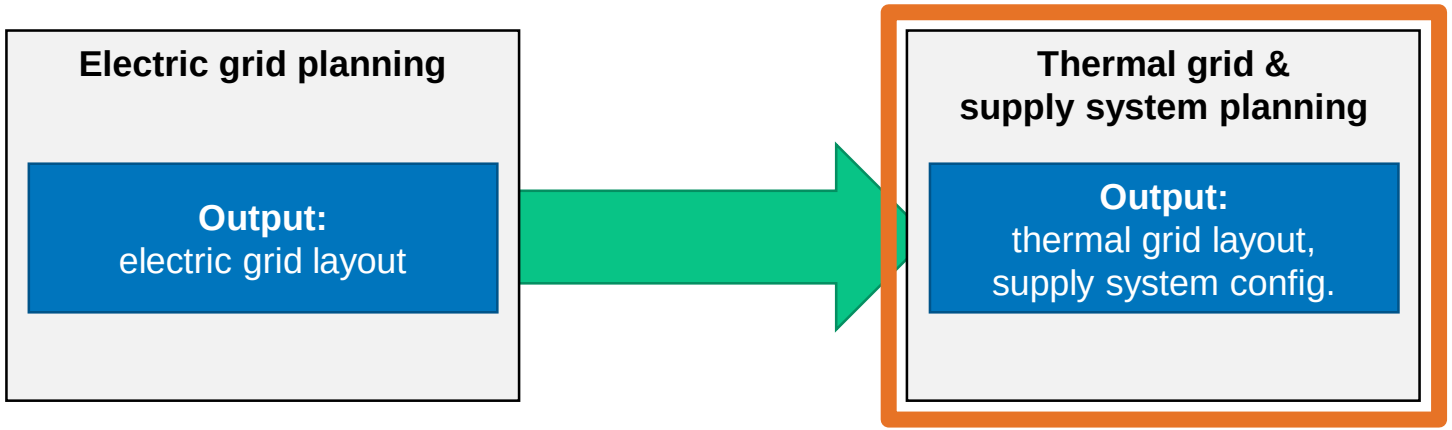
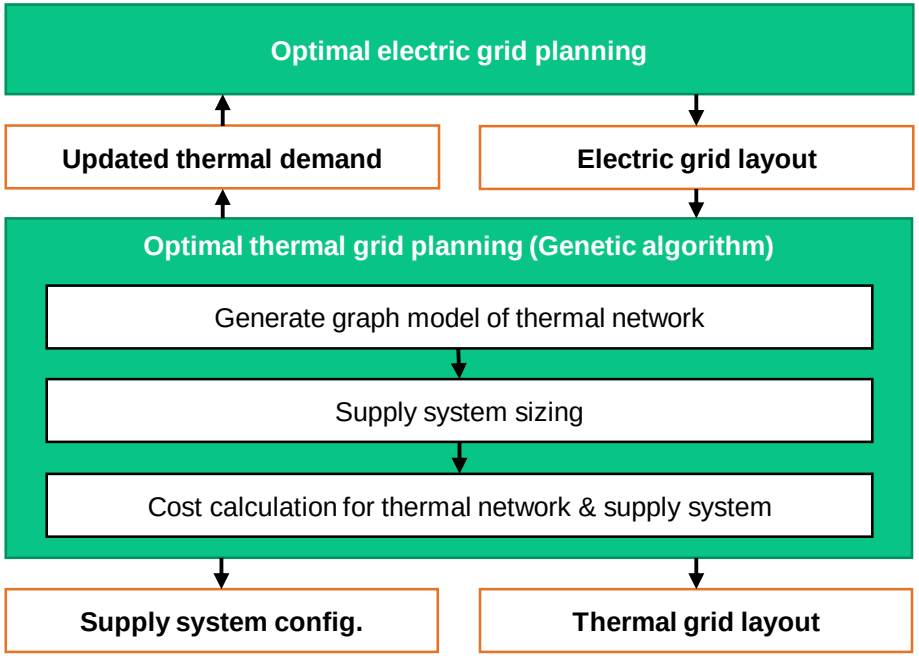


Methodology: Thermal Grid and Supply System Planning



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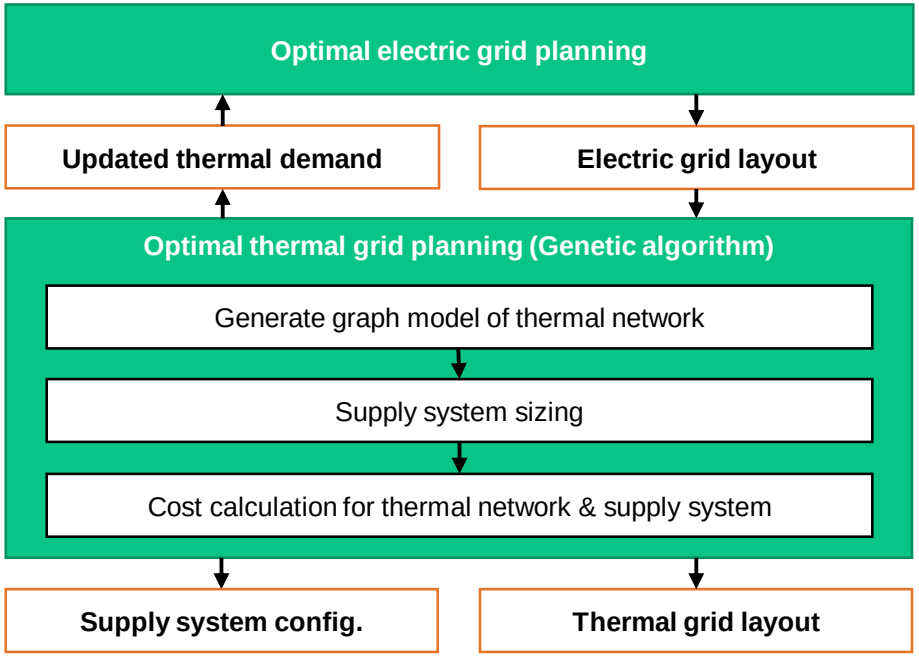

Building Connectivity	PV coverage (roof)	Major Supply System
70%	45%	Absorption Chiller

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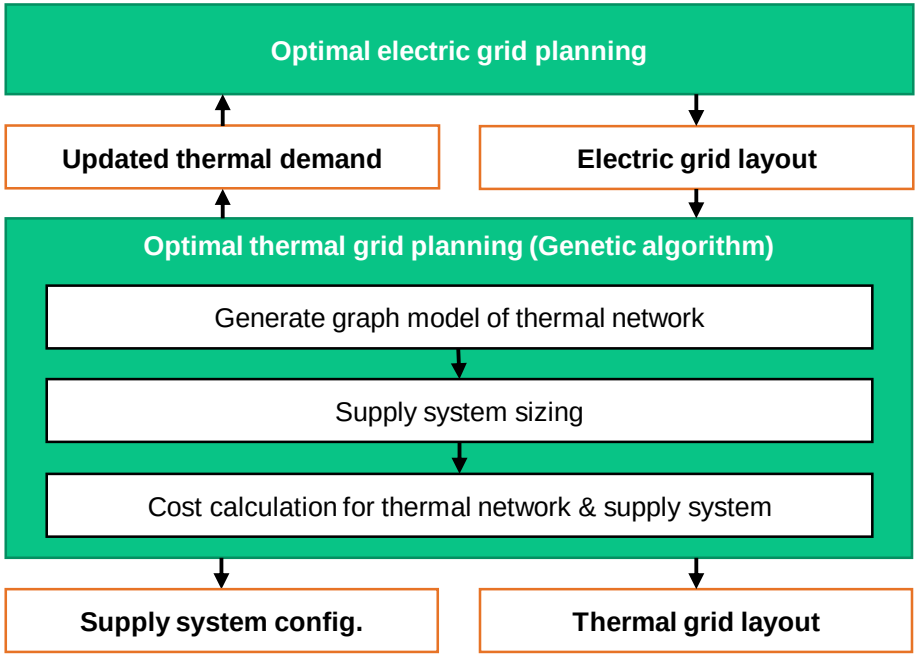
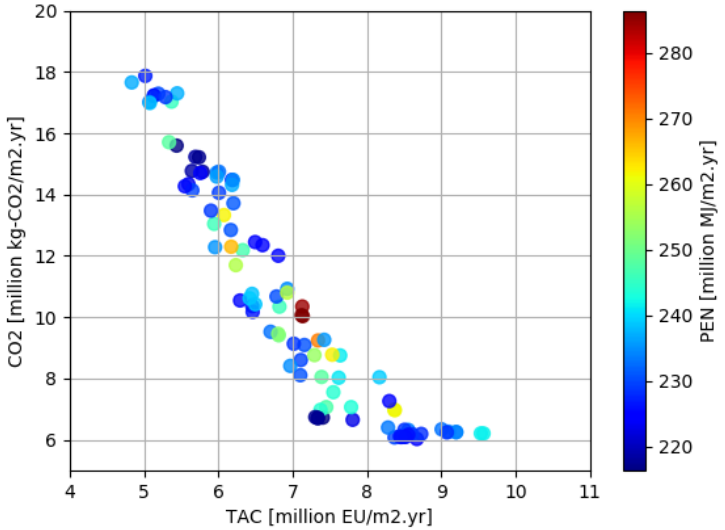
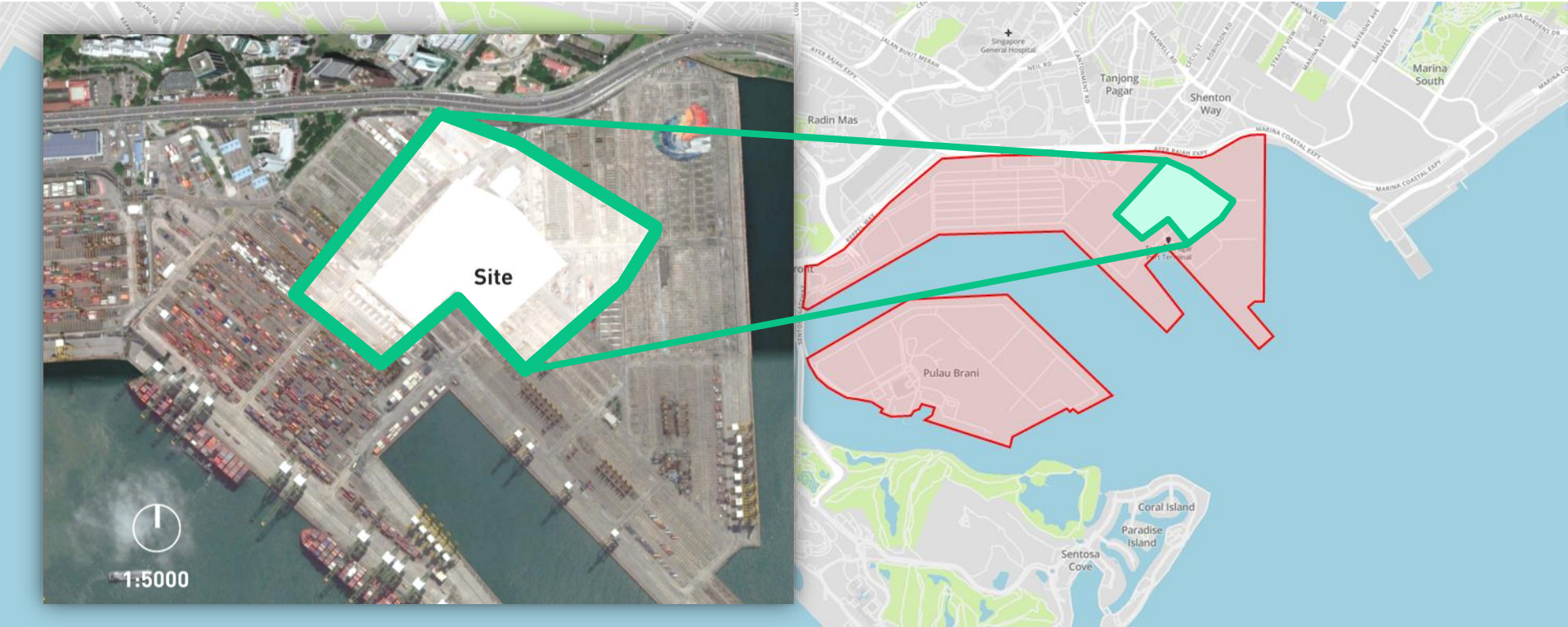




Case Study: New Town – Tanjong Pagar Water Front



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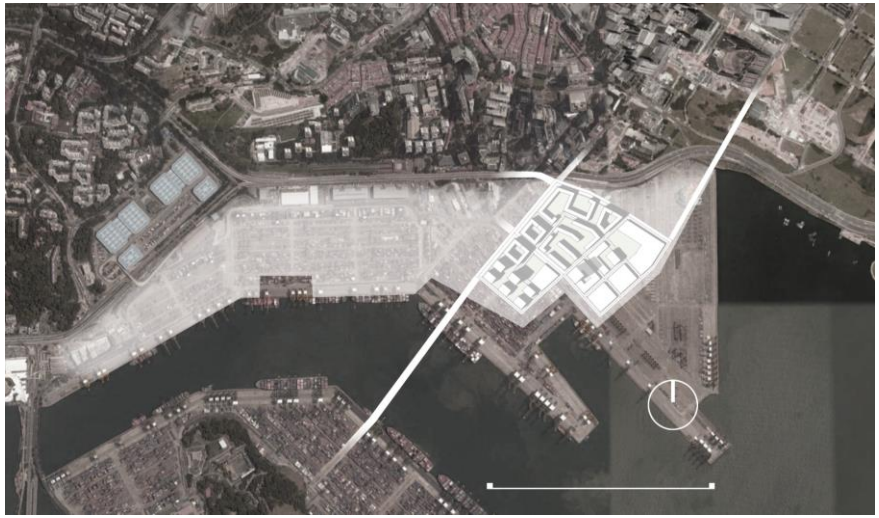


MIXed-use

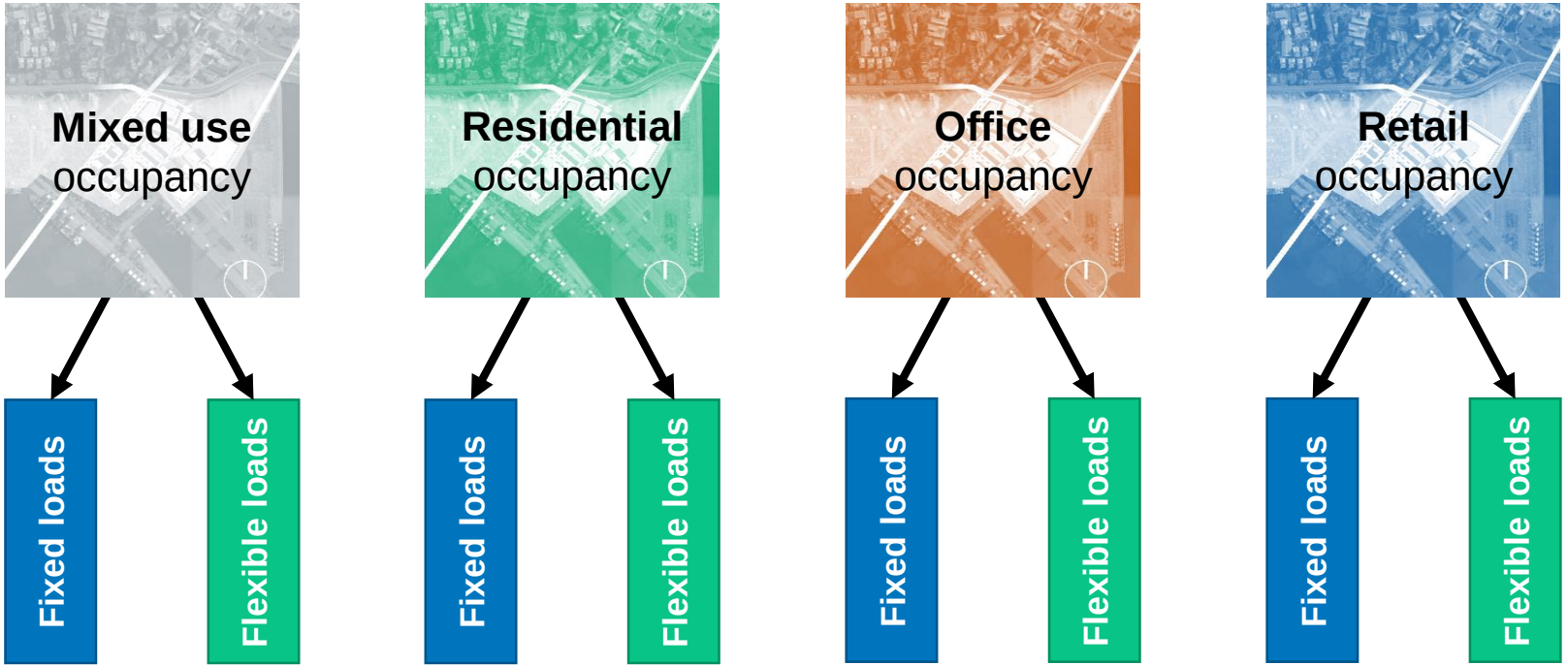
GFA = 374, 237 sqm

FAR = 4.62

People = 34,513

Buildings = 10

Case Study: Scenarios



Results

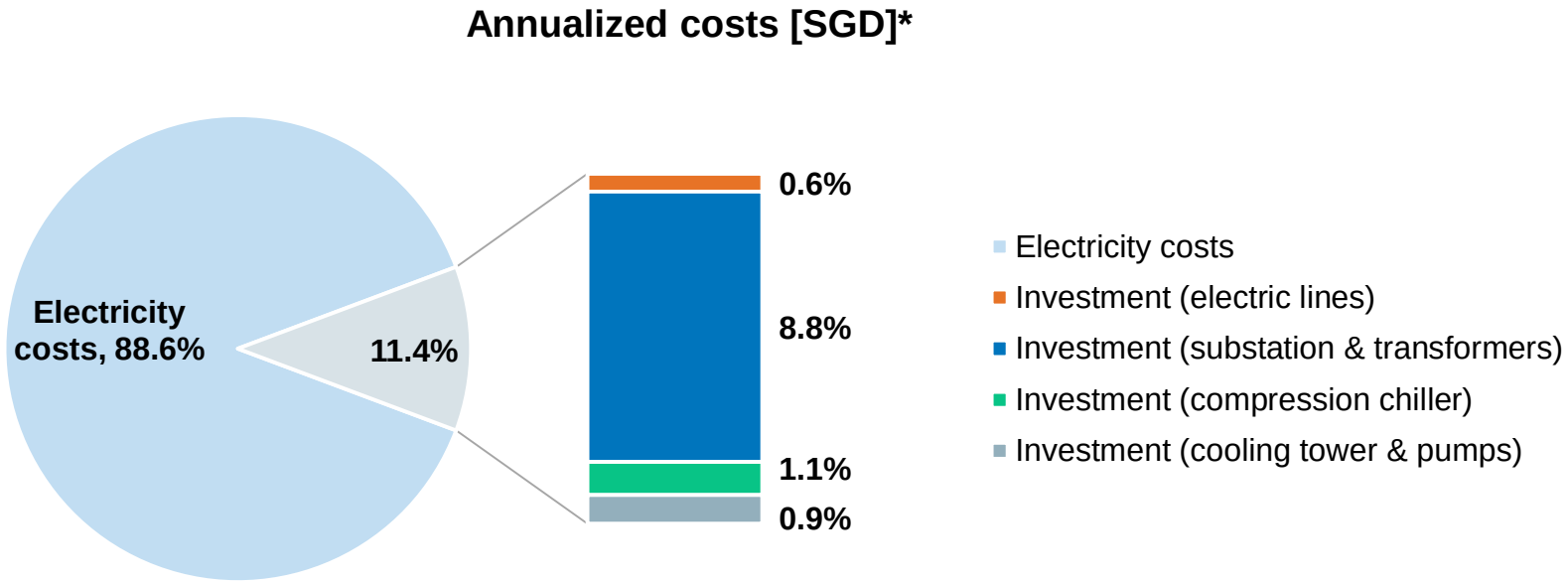
1. **Cost distribution** for fixed building loads

2. **Cost implications** of integrated planning and operation (Fixed vs. Flexible building loads)

3. **Energy implications** of integrated planning and operation (Fixed vs. Flexible building loads)

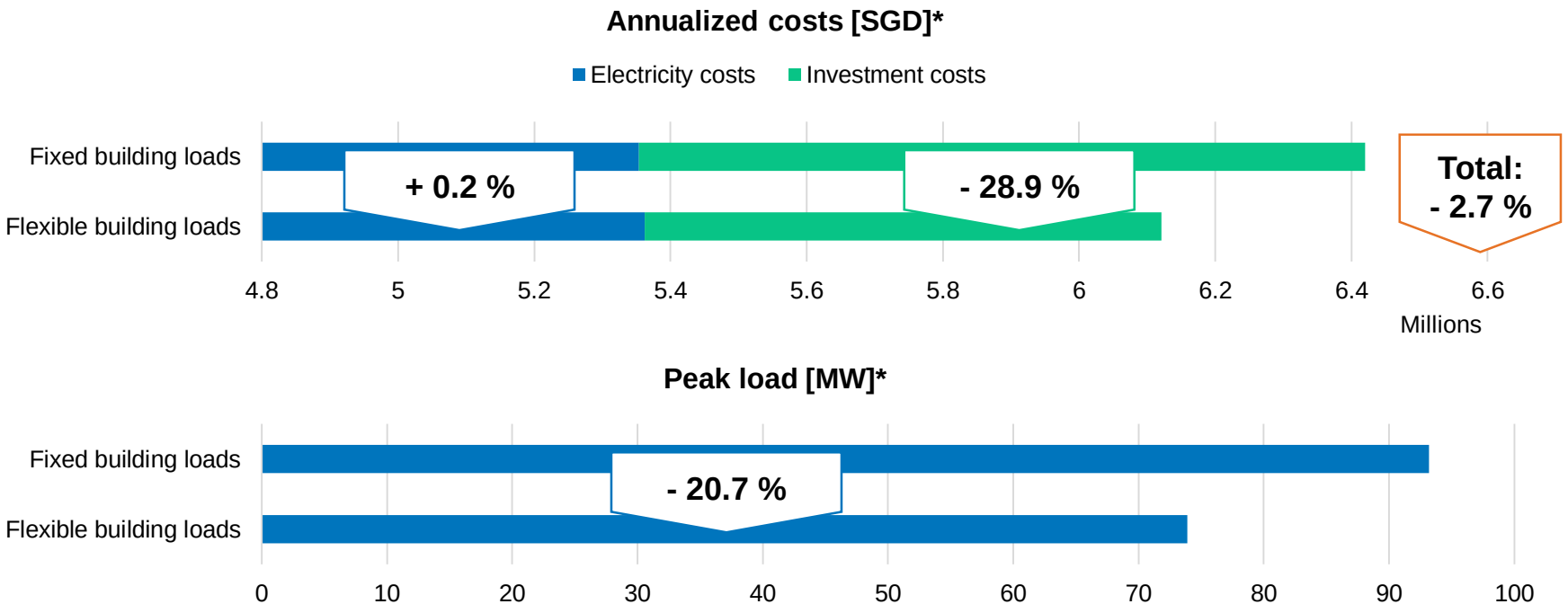
4. **Occupancy type dependency** of costs (Mixed, Office, Residential & Retail)

Results: Cost Distribution (Fixed Building Loads)



*(Preliminary results)

Results: Cost implications (Fixed vs. Flexible building loads)



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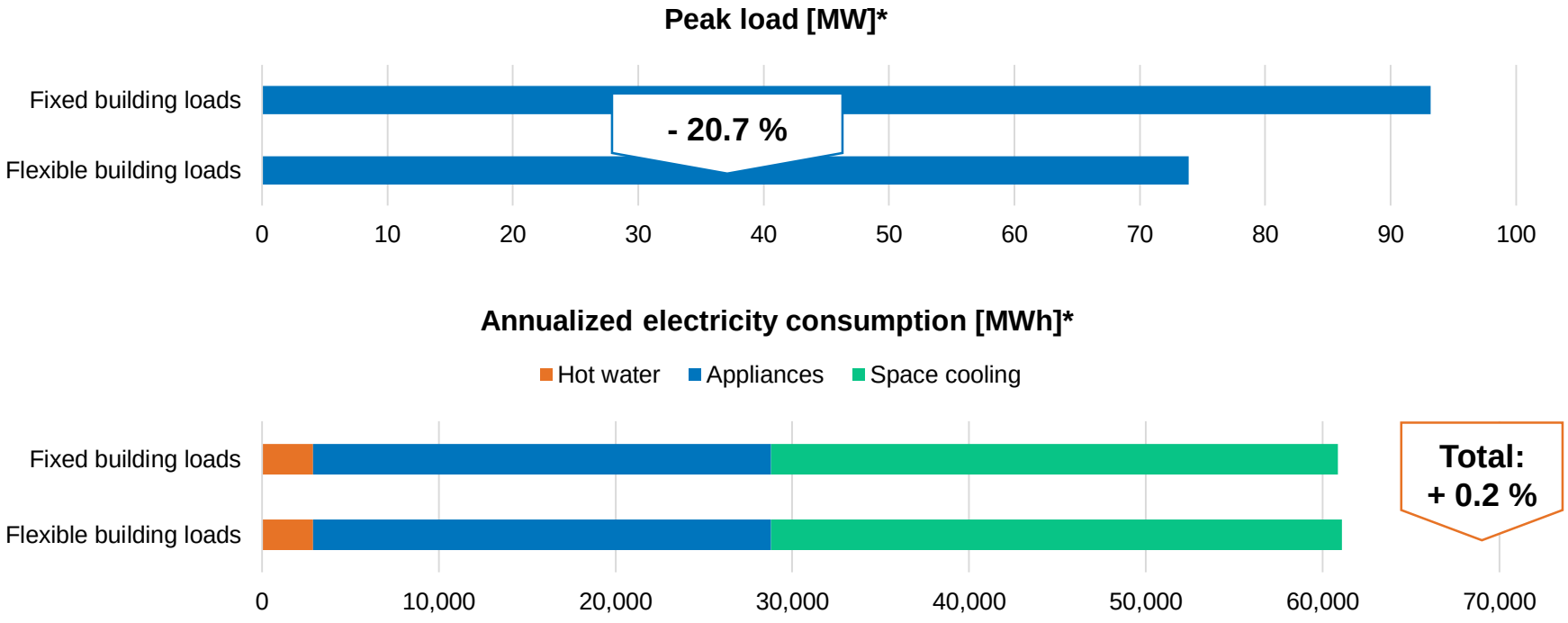
Results: Energy Implications (Fixed vs . Flexible Building Loads)

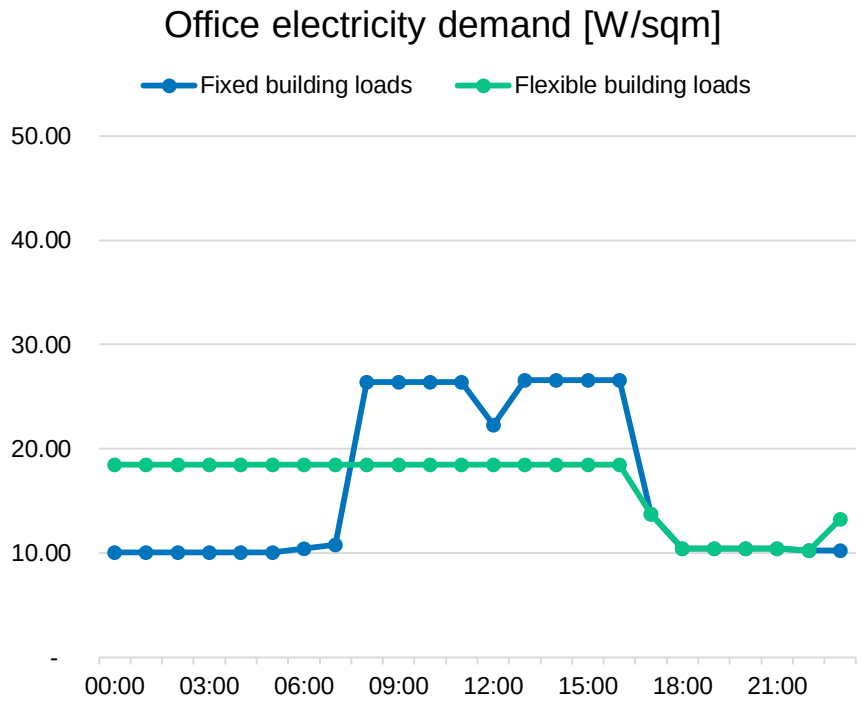


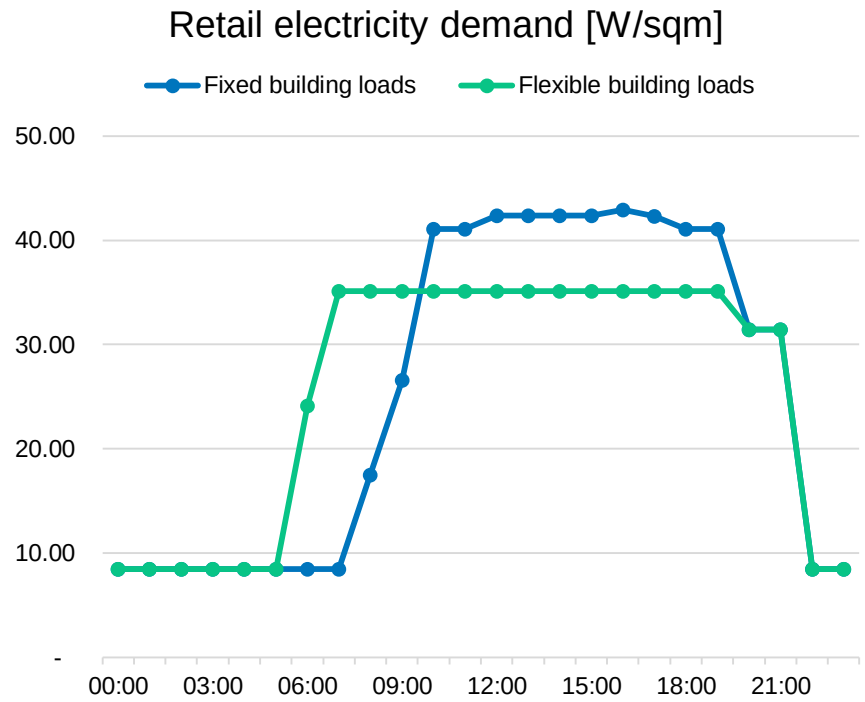
*(Preliminary results)

Results: Occupancy Type Dependency

	Mixed occupancy	Office occupancy	Residential occupancy	Retail occupancy
Annualized Total Costs	- 2.7 %	- 3.8 %	- 2.6 %	- 2.1 %
Investment Costs	**- 28 %**	**- 31 %**	**- 21 %**	**- 19 %**

Results: Occupancy Type Dependency





Conclusions

1. The **impact of flexible resources on the district energy system planning** is tested by using flexible building models at a pilot scale.

2. A detailed **computational framework** for generating **district energy systems** for neighbourhoods **with flexible buildings** has been developed and presented

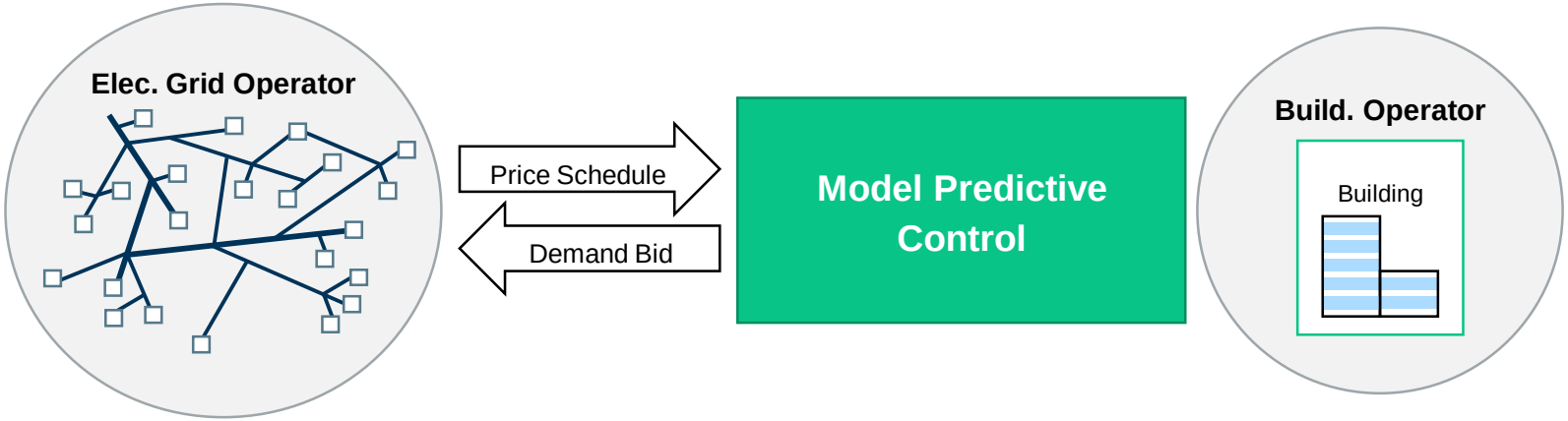
3. Flexible building loads **could decrease the investment cost (- 28 %)*** of the energy systems by **decreasing the peak load**. This comes at the cost of **increased electricity consumption (+ 0.2 %)***.

4. Of all occupancy types, **offices allow for the biggest decrease in investment costs (- 31 %)*.**

***(Preliminary results)**

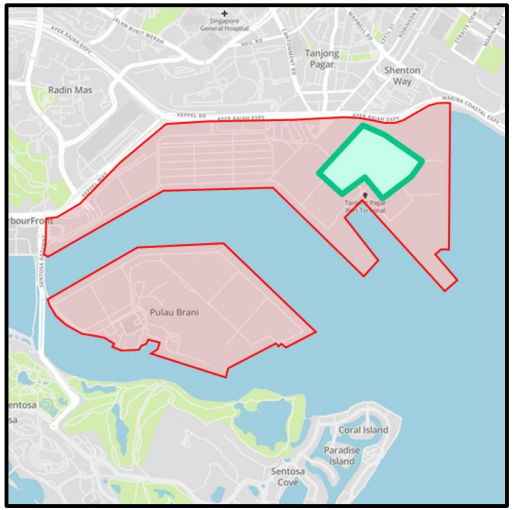
What about Implementation & Operation?

- Electric grid operation:
  - Distribution grid market, with a bid and clearing structure similar to the transmission level
- Building operation:
  - Model predictive control (MPC) for air-condition system control
  - Allows for consideration of dynamic electricity prices
  - MPC is actively being distributed by start-ups (e.g. Meteoviva) & trialed by BMS providers (e.g. Siemens)

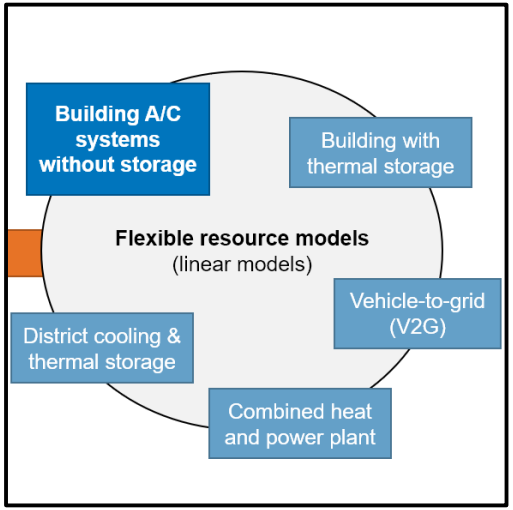


What is the Future of CONCEPT?

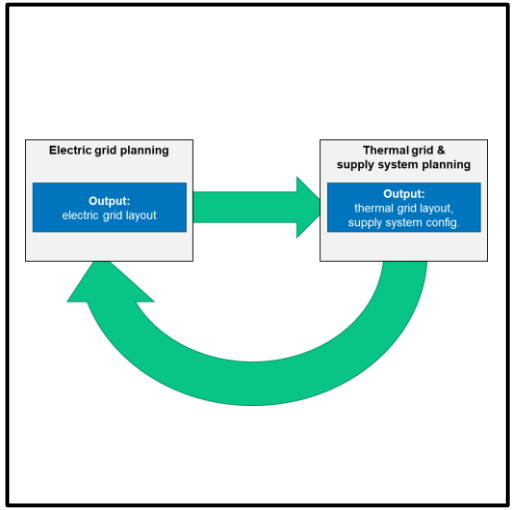
Size

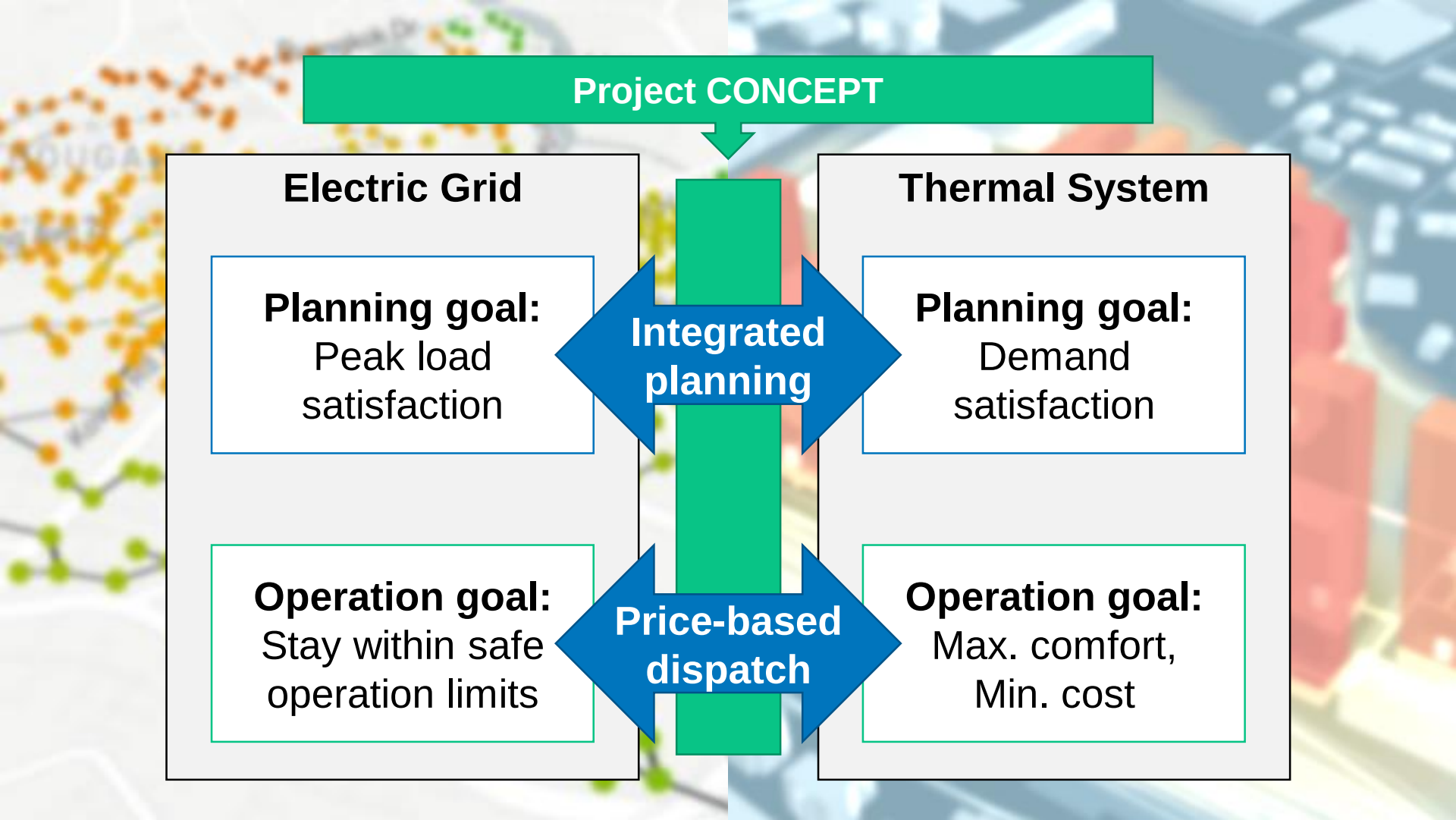


Extension



Feedback




Project CONCEPT
Electric Grid
Thermal System
Planning goal:
Peak load satisfaction
Integrated planning
Planning goal:
Demand satisfaction
Operation goal:
Stay within safe operation limits
Price-based dispatch
Operation goal:
Max. comfort,
Min. cost